

UNITED STATES PATENT APPLICATION

Of

PARK, Yong Cheol and KIM, Sung Dae

for

WRITE-ONCE OPTICAL DISC AND METHOD FOR MANAGING SPARE AREA  
THEREOF

[0001] This application claims the benefit of the Korean Application Nos. 10-2003-0010924 filed on 02/21/2003, and 10-2003-0065204 filed on 09/19/2003 which are hereby incorporated by reference.

## **BACKGROUND OF THE INVENTION**

### **Field of the Invention**

[0002] The present invention relates to a write-once optical disc and a method for managing spare area thereof, and more particularly, to a method for allocating a spare area to reduce or expand the allocated spare area.

### **Discussion of the Related Art**

[0003] As optical recording mediums, optical discs having a large capacity of data recorded thereon are widely being used. Among them, a new high-density digital versatile disc (HD-DVD), for instance, a blu ray disc (Blu-ray Disc) that can record and store video data of high quality and audio data of high fidelity for a long term period has been recently developed.

[0004] The blu-ray disc employing a next-generation HD-DVD technology is a next-generation optical recording solution that can store data to such a degree remarkably exceeding the storage

capacity of a conventional DVD, and a technical specification of international standard for HD-DVD has been recently regulated.

[0005] Related with this, various standards related with the blu-ray disc are prepared, and various standards for a write-once blu-ray disc (BD-WO) are being prepared following a rewritable blu-ray disc (BD-RE).

[0006] FIG. 1 schematically illustrates a structure of a recording area of a rewritable blu-ray disc (BD-RE). FIG. 1 illustrates, for example, a structure of a recording area of a single-layer disc having one recording layer. The disc is distinguished when viewed from the inner periphery thereof as a lead-in area, a data area and a lead-out. Further, the data area is provided with an inner spare area (ISA0) and an outer spare area (OSA0) respectively disposed at the inner and outer peripheries to replace a defective area. A user data area for recording user data therein is provided between the spare areas.

[0007] While data is recorded on the rewritable blue-ray disc (BD-RE), if there exists the defective area in the user data area, data recorded in the defective area is transferred to and replaced and recorded in the spare area. Additionally, position information related with the defective area, that is, position informations related with the defective area and a replacement area and the like is recorded in defect management areas (DMA 1, 2, 3, 4) provided for the lead-in/out areas to perform defect

management. The BD has a cluster as a minimal recording unit recorded thereon. One cluster is comprised of total 32 sectors, and one sector is comprised of 2048 bytes.

[0008] Since rewriting can be performed even in any area of the rewritable disc, an entire area of the disc can be used randomly irrespectively of a specific recording manner. Also, since the defect management information can be rewritten even in the defect management area (DMA), it does not matter even though only a predetermined size of the defect management area is provided. In particular, the BD-RE allocates and uses 32 clusters as the defect management area (DMA).

[0009] However, in the write-once disc, since writing can be made once on the disc, the recording manner is not only much limited, but also the defect management becomes one of important matters when data is recorded on a high-density write-once disc such as the recent BD-WO. Accordingly, even the write-once disc needs a management area to record information on defect management and disc management, and especially the write-once optical disc needs a larger management information recording area with comparison to the rewritable disc due to the property of 'write-once'. Like the rewritable optical disc, the write-once optical disc also needs a larger spare area than the rewritable optical disc so as to enable the defect management and the (logical) overwriting function.

[0010] However, since any of currently published regulations on the conventional write-once optical disc (ex. CD-R, DVD-R etc.) does not refer to a case where the spare area and the defect management area are both provided, preparation of new unified regulations is required for satisfying the above-mentioned requirements.

#### SUMMARY OF THE INVENTION

[0011] Accordingly, the present invention is directed to a write-once optical disc and a method for managing a spare area thereof that substantially obviate one or more problems due to limitations and disadvantages of the related art.

[0012] An object of the present invention is to provide a method for managing a spare area and a defect management area in a write-once optical disc, and a recording/reproducing apparatus related to the method, in particular, to provide a method for flexibly reducing or expanding the size of a spare area and/or a defect management area.

[0013] Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the

structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0014] To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, there is provided a method for managing a spare area of a write-once optical disc possibly having a temporary defect management area within one or more spare areas, the method comprising the steps of: allocating one or more spare areas including the temporary defect management area at an initial status of the optical disc; and during use of the optical disc, expanding the spare area allocated including the temporary defect management area to set a new spare area.

[0015] In an aspect of the present invention, there is provided a method for managing a spare area of a write-once optical disc possibly having a temporary defect management area within one or more spare areas, the method comprising the steps of: allocating only the spare area not including the temporary defect management area at an initial status of the optical disc; and during use of the optical disc, additively allocating the spare area including the temporary defect management area.

[0016] In another aspect of the present invention, there is provided a method for managing a spare area of a write-once optical disc possibly having a temporary defect management area within one or more spare areas, the method comprising the steps

of: allocating one or more spare areas including the temporary defect management area at an initial status of the optical disc; and during use of the optical disc, reducing an area except for the temporary defect management area in the spare area allocated including the temporary defect management area to set a new spare area.

[0017] In another aspect of the present invention, there is provided a method for managing a spare area of a write-once optical disc possibly having a temporary defect management area within one or more spare areas, the method comprising the steps of: allocating an expanded area discriminated from the spare area and a user data area; and during use of the optical disc, expanding the spare area and the user data area into the expanded area as necessary.

[0018] In another aspect of the present invention, there is provided a write-once optical disc provided with a lead-in area and a data area, at least one or more spare areas including a temporary defect management area being allocated in the data area, a new spare area being possibly set by expanding or reducing the spare area allocated including the temporary defect management area.

[0019] In another aspect of the present invention, there is provided a write-once optical disc provided with a lead-in area and a data area, the data area being provided therein with a

spare area and a user data area, and further provided with a separate expanded area such that the spare area or the user data area is expandable as necessary.

[0020] In another aspect of the present invention, there is provided an optical record reproducing apparatus of a write-once optical disc comprising: a control part for determining whether or not a spare area is additively allocated; and a recording/reproducing part for expanding a spare area including a temporary defect management area when it is necessary to additively allot the spare area depending on the determination, and setting a new spare area.

[0021] In another aspect of the present invention, there is provided an optical record reproducing apparatus of a write-once optical disc comprising: a control part for determining whether or not an allocated spare area is reduced; and a recording/reproducing part for reducing a spare area including a temporary defect management area when it is necessary to reduce the spare area depending on the determination, and setting a new spare area.

[0022] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.



### BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0024] FIG. 1 schematically illustrates a conventional rewritable optical disc structure;

[0025] FIG. 2 illustrates a single layer structure of an write-once optical disc according to the present invention;

[0026] FIG. 3 illustrates a dual layer structure of an write-once optical disc according to the present invention;

[0027] FIGs. 4A to 4C illustrate a method for managing spare area according to a first embodiment of the present invention;

[0028] FIGs. 5A and 5B illustrate a method for managing spare area according to a second embodiment of the present invention;

[0029] FIGs. 6A and 6B illustrate a method for managing spare area according to a third embodiment of the present invention;

[0030] FIGs. 7A to 7D illustrate a method for managing spare area according to a fourth embodiment of the present invention;  
and

[0031] FIG. 8 illustrates a record reproducing apparatus of an inventive write-once optical disc.

### DETAILED DESCRIPTION OF THE INVENTION

[0032] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0033] For description convenience, a write-once optical disc is exemplified with a blu-ray disc (BD-WO).

[0034] Together with this, the terminology of the present invention employs generally popularized terms if possible. However, in a specific case, terms are arbitrarily selected by the inventor. In this case, since meanings of the terms are defined in detail in corresponding descriptions, it is understood that the invention should be understood with the meanings of the terms, not simple names of the terms.

[0035] FIGs. 2 and 3 concretely illustrate structures of write-once optical discs according to the present invention.

[0036] The inventive write-once optical disc is characterized by including a spare area and a temporary disc management area (TDMA) for defect management. Hereinafter, there will be in detail described a method how to allocate the spare area and the defect management area within the optical disc.

[0037] FIG. 2 illustrates a structure of a write-once optical disc (BD-WO), i.e., a single layer disc having one recording layer, and has the following two characteristics compared with the conventional rewritable optical disc (BD-RE).

[0038] First, since the write-once optical disc by nature has to secure many areas on which a variety of management information of the disc are recorded, it includes a plurality of Temporary Defect Management Areas (hereinafter, referred to as "TDMA") as well as the conventional Defect Management Area (hereinafter, referred to as "DMA"). In particular, TDMA's are generally classified into two types: primary TDMA (hereinafter, referred to as "PTDMA") having a fixed size (for example, 2048 clusters) within the lead-in area; and additional TDMA (referred to as "ATDMA") having a variable size within the outer spare area (OSA0) among the spare areas of the data area. They are respectively named as the PTDMA0 and the ATDMA0.

[0039] The PTDMA0 should be inevitably allocated to the lead-in area at the fixed size (for example, 2048 clusters) at an initial status of the disc, and the ATDMA0 can be selectively allocated or not allocated. In the course of allocating, the size (B) of the ATDMA0 can be determined variously, and would be appropriate when having a specific-rated size (for example,  $B = A/4$ ) with respect to the size (A) of the spare area (OSA0). That is, the inventive write-once optical disc includes a plurality of

the temporary defect management areas (TDMAs) in addition to the defect management area (DMA). The TDMAs are characterized by including the PTDMA allocated in the fixed size and the ATDMA allocated to a specific spare area in the variable size.

[0040] Second, the size of the spare area is set flexibly. In other words, the flexible setting of the size of the spare area is meant by that it is possible to expand or reduce the size of an initially allocated spare area. This is because many spare areas are necessary so as for the write-once optical disc to perform the defect management and enable to perform an additional function (for instance, relates to a logic overwriting in BD-WO, in case of BD-WO, it is impossible to physically rewrite information on a specific area but when it is wished to rewrite information on a specific area where recording has been completed, the area is replaced by a spare area and recorded).

[0041] Also, to prevent disorder that may be caused when all the spare areas are utilized flexibly, it is allowed to make only the spare area existing in the end portion of the user data area flexible. The spare area existing in the end portion of the user data area corresponds to outer spare area (OSA0) when the single layer disc as shown in FIG. 2 is employed, and corresponds to inner spare area (ISA1) of the second recording layer (Layer 1) when the dual layer disc as shown in FIG. 3 is employed. In other words, the spare area, which is flexibly used in the entire areas

of the disc, exists only one, and the remaining spare area is fixed to an initially allocated size, later expanded, or reduced to a flexible size.

[0042] In addition, the spare area is expandable to a predetermined maximum expandable size to thereby prevent the spare area from being expanded endlessly. For instance, if it is assumed that a preferable maximum expandable size of the spare area is up to the half of the entire data areas, the maximum expandable size of the spare area in the single layer as shown in FIG. 2 becomes about 12 GB ( $768 \times 256$  clusters). However, it is apparent that the maximum expandable size can be set to another size in regulating standards.

[0043] Further, for the convenience of description, it is made clear that alphabets (A, B, C, D, N, P, L, Q, X, Y, Z, K and the like) representing the respective areas of the disc are marked as information indicating sizes of corresponding areas.

[0044] FIG. 3 illustrates a dual layer structure having two recording layers in a write-once optical disc according to the present invention. The dual layer structure includes a first recording layer (Layer0) and a second recording layer (Layer1). Each of the first and second recording layers includes PTDAM0 (Layer0) and PTDMA1 (Layer1) having a fixed size. In the dual layer structure, total four spare areas are allocatable, and specifically, ISA0 and OSA0 are respectively allocated in inner

periphery and outer periphery of the first recording layer (Layer0) while ISA1 and OSA1 are respectively allocated in inner periphery and outer periphery of the second recording layer (Layer1). Especially, ATDMAs exist only within OSA0/OSA1/ISA1 among these areas, and are respectively named ATDMA0/ATDMA1/ATDMA2. Also, as described in FIG. 2, the spare area that is used flexibly corresponds only to the inner spare area (ISA1) of the second recording layer existing in an end of user data area, and is allowed to be expandable to maximum expandable size, thereby preventing the flexibly used spare area from being expanded endlessly. In FIG. 3, alphabets C, D, L, Q correspond to size information of corresponding areas. Especially, it is desirable that the size (D) of ATDMA0 and ATDMA1 has a size corresponding to about a quarter of the size (C) of OSA0 and OSA1. Also, it is desirable that the size (Q) of ATDMA2 has a size corresponding to about a quarter of the size (L) of ISA1. These sizes are however items that should be determined by standards, and it is obvious that these sizes may be changed.

[0045] Hereinafter, a method for flexibly allocating spare areas including a temporary defect management area according to the present invention will be described through various embodiments referring FIGs. 4 to 7.

[0046] Also, although the following embodiments exemplarily illustrate only the single layer structure as in FIG. 2 for the

convenience of description, it will be apparent that the dual layer structure shown in FIG. 3 can be also applied. In case of the dual layer structure, ISA1 not OSA1 is flexibly used as described previously.

[0047] FIGs. 4A to 4C illustrate a method for managing spare area according to a first embodiment of the present invention. In this method, whenever the spare area is expanded, ATDMA is allocated too. In other words, FIGs. 4A to 4D show that whenever the OSA0 is expanded, ATDMA contained in the expanded OSA0 is allocated together with the OSA0.

[0048] First, in FIG. 4A, OSA0 (initial) including ATDMA0 is allocated at an initial status such that the ATDMA0 has a size (P1) corresponding to a quarter of an overall size (N1) of OSA0. The term 'initial' means a state before an initial recording of a user is carried out. Accordingly, the allocation of the initial OSA0 as above may be performed by a disc manufacturer or by a user. In other words, the user may format the disc to initialize the allocation of the OSA0.

[0049] After the above initial state, when it is necessary to expand the spare area while the disc is used, an additional allocation may be possible by a command of a control part (see numeral 20 of FIG. 8) of a recording/reproducing apparatus or a command of a user, so that the entire spare area can be expanded.

[0050] Again referring to FIG. 4A, in a first extension, OSA0 is made to a size of  $N_2$  and ATDMAS1 (which is apparently different than ATDMA1 existing in the dual layer of FIG. 3) is made to a size of  $P_2$  such that the size of  $P_2$  corresponds to a quarter of the size of  $N_2$ . Likewise, in a second extension, OSA0 is made to a size of  $N_3$  and ATDMAS2 is made to a size of  $P_3$  such that the size of  $P_3$  corresponds to a quarter of the size of  $N_3$ .

[0051] In the above allocation method, the size ( $N_2$ ) of the first extension-allocated OSA0 and the size ( $N_3$ ) of the second extension-allocated OSA0 can be made flexible, i.e., different from each other or identical ( $N_2=N_3$ ) to each other within the maximum expandable size.

[0052] FIG. 4B illustrates a case that OSA0 (initial) is allocated at an initial status but ATDMA0 is not allocated within OSA0 (initial). In other words, since ATDMA can be allocated selectively within OSA0 or be not allocated, it is possible that OSA0 (initial) no having ATDMA is allocated at the initial status as shown in FIG. 4B.

[0053] After the above initial status, i.e., when it is necessary to expand the spare area while the disc is used, OSA0 including ATDMA will be allocated as in FIG. 4A.

[0054] In other words, in FIG. 4B, in a first extension, OSA0 is made to a size of  $N_2$  and ATDMAS0 is made to a size of  $P_2$  such that the size of  $P_2$  corresponds to a quarter of the size of  $N_2$ .



Likewise, in a second extension, OSA0 is made to a size of N3 and ATDMAS2 is made to a size of P3 such that the size of P3 corresponds to a quarter of the size of N3.

[0055] In the above allocation method, the size (N2) of the first extension-allocated OSA0 and the size (N3) of the second extension-allocated OSA0 can be made flexible, i.e., different from each other or identical ( $N2=N3$ ) to each other within the maximum expandable size.

[0056] FIG. 4C illustrates a case that OSA0 is not allocated at an initial status. If OSA0 is not allocated at the initial status, the disc performs defect management only using ISA0 at the initial status and then allocates OSA0 to an outer periphery when spare area is additionally needed.

[0057] After the above initial status, i.e., when it is necessary to expand the spare area while the disc is used, OSA0 including ATDMA will be allocated as in FIGs. 4A and 4B.

[0058] In other words, in FIG. 4C, in a first extension, OSA0 is made to a size of N1 and ATDMAS0 is made to a size of P1 such that the size of P1 corresponds to a quarter of the size of N1. Likewise, in a second extension, OSA0 is made to a size of N2 and ATDMAS1 is made to a size of P2 such that the size of P2 corresponds to a quarter of the size of N2. Also, in a third extension, OSA0 is made to a size of N3 and ATDMAS2 is made to a

size of P3 such that the size of P3 corresponds to a quarter of the size of N3.

[0059] In the above allocation method, the size (N1) of the first extension-allocated OSA0, the size (N2) of the second extension-allocated OSA0 and the size (N3) of the third extension-allocated OSA0 can be made flexible, i.e., different from one another or identical ( $N1=N2=N3$ ) to one another within the maximum expandable size.

[0060] FIGs. 5A and 5B illustrate a method for managing spare area according to a second embodiment of the present invention.

[0061] In this second embodiment, OSA0 (initial) is allocated to a maximum expandable size that is allowable at an initial status by a disc, together with ATDMA0. Afterwards, if necessary, OSA0 (initial) is reduced. In this case, OSA0 is reduced only at a remaining area except for ATDMA0, but ATDMA0 is not altered from an initially allocated size. The size (Y1) of ATDMA0 is set at the initial status to be a quarter of the size (X1) of OSA0 (initial). Accordingly, the size (Y1) of ATDMA0 is like to be a much larger value than the size (P1) of ATDMA0 in the first embodiment. In other words, at the initial status of the disc, a sufficiently large ATDMA0 (Y1) is allocated and then the size of the ATDMA0 is not changed.

[0062] FIG. 5B illustrates that OSA0 (initial) is reduced during use of a disc when its reduction is necessary after the

initial status. If OSA0 is reduced, an adjacent user data area is expanded but the size (Y1) of ATDMA0 is not changed.

[0063] In other words, the overall size (X2) of OSA0 is reduced to 'X1 - K1' by the size (K1) of OSA0, but the size (Y1) of ATDMA0 is fixed, i.e., is not changed. However, the ratio of the size (Y1) of ATDMA0 to the size (X1) of OSA0 (initial) is changed from the 1/4 relationship by the reduced allocation.

[0064] The above second embodiment has a burden that ATDMA0 and OSA0 (initial) having a large size are allocated at the initial status, but it has an advantage that it is convenient to manage ATDMA0 because the size of ATDMA0 is not changed and the additional allocation of ATDMA0 is not performed.

[0065] FIGs. 6A and 6B illustrate a method for managing spare area according to a third embodiment of the present invention.

[0066] In this third embodiment, OSA0 (initial) is allocated including ATDMA0 of which size is a quarter ( $\max/4$ ) of a maximum expandable size that is allowable by a disc. Afterwards, if necessary, OSA0 (initial) is expandable. In this case, OSA0 is expanded only at a remaining area except for ATDMA0, but ATDMA0 is not altered from an initially allocated size.

[0067] FIG. 6B illustrates that OSA0 (initial) is expanded during use of a disc when its extension is necessary after the initial status. If OSA0 is expanded, an adjacent user data area is reduced but the size (Y1) of ATDMA0 is not changed.

[0068] In other words, the overall size (Z2) of OSA0 is expanded to 'Z1 + K2' by the size (K2) of OSA0, but the size (Y1) of ATDMA0 is fixed, i.e., is not changed. In other words, the ratio of the size (Y1) of ATDMA0 to the size (Z1) of OSA0 (initial) is not the 1/4 relationship but if the OSA0 is expanded to the maximum expandable size, the size (Y1) of ATDMA0 will be changed at a ratio of 1/4 size (max/4).

[0069] Like the second embodiment, the above third embodiment has a burden that ATDMA0 and OSA0 (initial) having a large size should be allocated at the initial status, but it has an advantage that it is convenient to manage ATDMA0 because the size of ATDMA0 is not changed and the additional allocation of ATDMA0 is not performed although OSA0 is expanded flexibly.

[0070] While in the second and third embodiments, cases that the size (Y1) of the initial ATDMA0 is a quarter of the maximum expandable size of OSA0 has been described, it will be apparent that a specific ratio other than the above ratio can be employed.

[0071] FIGs. 7A to 7D illustrate a method for managing a spare area according to a fourth embodiment of the present invention. In addition to a user data area and a spare area, an expandable area is further provided within the disc. If necessary, an expansion of the user data area or the spare area (except for ATDMA) or the ATDMA is allocated.

[0072] FIG. 7A illustrates an initial status of an overall disc structure according to the fourth embodiment of the present invention. First, an initial OSA0 is allocated including an ATDMA0, and an expandable area is allocated between the user data area and the OSA0. As shown in FIG. 2 and as described in the above embodiment, it is good enough for the expandable area to have a maximum expandable size.

[0073] FIG. 7B illustrates a case that the user data area is expanded in the initial status. In other words, in case an additional allocation of the user data area is necessary, the user data area is allocated toward the expandable area as much as necessary. Of course, in this case, it does not matter that the user data area is always expanded with the equal size by formalizing the size to be allocated at a time. Since the user data area is expanded toward the inside of the expandable area, there is no change in the size of the OSA0.

[0074] FIG. 7C illustrates a first case that the OSA0 is expanded in the initial status. Specifically, since the ATDMA0 is distinguished from the remaining area within the OSA0, this embodiment focuses on the expansion of the remaining area except for the ATDMA0. Of course, in this case, it does not matter that the user data area is expanded with the equal size by formalizing the size to be allocated at a time. Since the user data area is expanded toward the inside of the expandable area, there is no

change in the size of the user data area. In addition, the ATDMA0 maintains the same size P1 because the ATDMA0 is not expanded.

[0075] FIG. 7D illustrates a second case that the OSA0 is expanded in the initial status. Specifically, only the ATDMA allocated within the initial OSA0 is expanded toward the expandable area. Here, the expansively allocated ATDMA is named an "ATDMA1" in order to distinguish it from the initially allocated ATDMA0. A size P2 allocated to the expanded ATDMA1 can be equal to or different from the size P1 allocated to the initially allocated ATDMA0. In addition, since only the ATDMA is expanded toward the inside of the expandable area, the user data area can maintain the same size without any change.

[0076] According to the fourth embodiment of the present invention, the additional area, that is, the expandable area, is provided in advance within the disc. Therefore, if necessary, any area can be expanded using the expandable area even during use of the disc, thereby improving efficiency in the use of the disc much more.

[0077] FIG. 8 illustrates a recording/reproducing apparatus for the optical disc according to the present invention. The apparatus of the present invention includes a recording/reproducing part 10 for recording/reproducing information on/from the optical disc, and a control part 20 for

controlling the recording/reproducing part 10. The control part 20 issues a command for recording or reproducing information on or from a specific area of the recording/reproducing part 10. Specifically, the recording/reproducing part 10 includes: an interface unit 12 for performing a communication with an exterior; a pickup unit 11 for directly recording or reproducing data on or from the optical disc; a data-processor 13 for receiving a reproduction signal from the pickup unit to restore it into desired signal value, or for modulating to-be-recorded signal into a signal to be recorded on the optical disc; a servo unit 14 for accurately reading out signal from the optical disc, or controlling the pickup unit 11 to accurately record the signal on the optical disc; a memory 15 for temporarily storing several information, including the management information, and data; and a micom 16 for controlling components of the recording/reproducing part 10.

[0078] Herein, a method for managing the spare area in the recording/reproducing apparatus according to the present invention will be described below in detail.

[0079] If the optical disc is loaded, the recording/reproducing part 10 checks the disc structure of the loaded optical disc. At this time, the recording/reproducing part 10 checks each size and location of the spare area and the ADTDMA and notifies the control part 20 of the information on the

checked size and location. Then, based on the notified information, the control part 20 determines in advance whether there is the possibility of the additional expansion (or reduction).

[0080] During use of the disc, if it is necessary to expand the spare area or the ATDMA, the control part 20 transmits an expansion command, including the expansion target and its size, to the recording/reproducing part 10. In other words, a substantial execution of the expansion command means that the size and position information of each area changed by the expansion of the spare area or the ATDMA are recorded on the disc as the management information.

[0081] In other words, as shown in FIG. 4A, if the OSA0 (including the ATDMA0) is first extension-allocated, the control part 20 commands the allocation of the OSA0 (1<sup>st</sup> extension). Then, the recording/reproducing part 20 completes the additional allocation by recording a value of a last LSN, a size and position information of the allocated ATDMA1 on a specific area of the disc according to the allocation command. Here, the "last LSN" is an end portion of the user data area changed by the allocation.

[0082] In the same manner, if the spare area is reduction-allocated as shown in FIG. 5B, the reduced allocation is completed by recording a value of a last LSN on a specific area



of the disc. Here, the "last LSN" is an end portion of the user data area changed by the reduced allocation. In FIG. 5B, since the ATDMA0 is not changed, the information on the position or size of the ATDMA0 is not changed due to the reduced allocation. Accordingly, the management information need not be recorded additionally.

[0083] As described previously, the present invention provides various methods for flexibly using spare area and/or temporary defect management area (ATDMA) if necessary in a write-once optical disc, it becomes possible to establish unified regulations on the structures of the spare area and temporary defect management area (PTDMA/ATDMA) applicable to the write-once optical disc, so that usage efficiency of the optical disc can be improved.

[0084] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.